the observer is easily able to estimate 10 different degrees of covering. From a record of the numbers representing these degrees of covering the areal percentages of the different species are readily established.

A summary of the methods employed, and a classification of vegetation upon the basis of life-forms and leaf-sizes, completes an article rich in suggestions to the ecologist seeking more accurate methods.—GEO. D. FULLER.

Susceptibility gradients.—Following his demonstration of axial metabolic gradients in animals and their relation to the course of development and individuation, CHILD entered upon a study of axiate plants, particularly the algae. His first paper[14] on axial gradients in algae appeared several years ago. His interesting and valuable observations[15] have been extended to include a considerable number of new forms, and the results are sufficiently uniform to warrant the general conclusion that plants and animals are essentially similar in respect to these axial susceptibility gradients.

Twenty-five species have been studied, 14 of which were considered in the earlier paper, and all of them show an axial gradient in susceptibility to injury and death from such agents as KCN, alcohol, ether, HCl, $HgCl_2$, $CuSO_4$, neutral red, temperature, etc. When killing concentrations are used, death occurs first in the apical region and proceeds basipetally in each axis. The susceptibility gradient is a general indicator of metabolic rates, death occurring soonest in the most active protoplasm. The susceptibility gradient is rather easily altered or reversed by external conditions, by advancing age, physiological isolation of cells and branches, and other factors. The ease with which such reversals occur indicates in some degree the sensitiveness of species.

He finds[16] that the unicellular and multicellular hairs, either branched or unbranched, which occur on some algae, possess the same kind of axial gradients as the main axis. In such forms as *Fucus* and *Castagnea*, in which the hairs have basal growth, the gradient is acropetal; but whenever the hairs grow apically the normal gradient is basipetal. Reversals may be induced in these hairs, also, especially with low concentrations of the susceptibility reagents. In some cases the agent may reverse the susceptibility to itself, or one agent may reverse the susceptibility to another agent. These results indicate clearly that hairs represent physiological axes, and the gradient of susceptibility appears to be one of the aspects of physiological polarity in all axes. When the axial gradients are reversed, these hairs often separate into their component cells, or the hairs drop from the main axes. Loss of hairs in laboratory material

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[14] CHILD, C. M., Axial susceptibility gradients in algae. BOT. GAZ. **62**:89–114. 1916.

[15] ———, Further observations on axial susceptibility gradients in algae. Biol. Bull. **31**:419–440. 1916.

[16] ———, Susceptibility gradients in the hairs of certain marine algae. Biol. Bull. **32**:75–92. 1917.

is undoubtedly associated with reversed gradients brought about by unfavorable conditions of confinement.

These changes in gradients of hairs were studied particularly in *Griffithsia*.[17] If conditions are not extreme, obliteration or reversal of the axial gradient is followed by cell separation, and the death of some of the cells, the death-rate being higher among isolated apical cells than among those more basally situated. The cells which do not die usually proceed to grow new apical cells, which are found to arise at the most susceptible end of the old cells. This is usually the *basal* end, because the normal gradient had been reversed before the cells were disconnected. Rhizoids, however, arise only on those parts of the cell which have the lowest metabolic rates or lowest susceptibility.

The general conclusion of all this work is summarized admirably in the words of the author: "The facts support the conclusion that a gradient in metabolic rate, protoplasmic condition, or whatever we prefer to call it, of which the susceptibility gradient is within certain limits an indicator, constitutes physiological polarity in protoplasm, and that such a gradient is not an inherent property of protoplasm, but may be determined and altered by external factors."

Students who desire to repeat some of these experiments for themselves will find a recent paper of interest.[18] The axial gradient may be very beautifully demonstrated colorimetrically by the use of dilute solutions of potassium permanganate. The protoplasm reduces the permanganate and takes on a brown color, which appears first and deepest in the most active regions. Concentrations of M/1000 to M/100,000 should be used for such experiments.—C. A. SHULL.

Biology and culture of the higher fungi.—Among recent contributions to our knowledge of this difficult subject is a paper by BOYER[19]. The first part deals with attempts at spore germination and culture of over 60 species, and the second gives in more detail the results of his work with *Morchella* and *Psaliota*.

He recognizes three types of higher fungi: (1) pure saprophytes, (2) facultative parasites, and (3) mycorhizal forms which are constantly associated with certain trees. Saprophytes, he finds, grow readily on culture media, and many give rise to carpophores; while many of the mycorhizal group cannot be grown in pure cultures on any of the many types of media tried. Between pure saprophytes and forms which will not grow on culture media he finds

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[17] CHILD, C. M., Experimental alteration of the axial gradient in the alga *Griffithsia Bornetiana*. Biol. Bull. **32**:213–233. 1917.

[18] ———, Demonstration of the axial gradients by means of potassium permanganate. Biol. Bull. **36**:133–147. 1919.

[19] BOYER, G., Études sur la biologie et la culture des champignons superieurs. pp. 116. *pls. 4. figs. 20.* Bordeaux. 1918.